

Implementation of a Relational Patient Record with Integration of Educational and Reference Information

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ABSTRACT

The clinician must identify pertinent diagnostic information and develop appropriate medical management plans in the context of rapidly changing research information, new therapeutic options and expanding diagnostic modalities. To assist in recognition of patterns relevant to diagnostic or therapeutic interventions, the medical record must be presented in a format that emphasizes important data interrelationships. Reference and educational information specifically pertinent to the case being reviewed must be immediately accessible.

A system that presents point of care patient centered clinical information, a summarized patient record, in a relational format with linked reference information has been developed. Data is acquired from the VA patient information database and provided over a PC network. At the time of data transfer, preliminary analysis and reorganization of data is performed such that interrelationships between laboratory, pharmacy and diagnostic information can be rapidly recognized. During data compilation reference and educational information is linked with patient data such that it can be accessed with a mouse click ("hotspot") when the record is subsequently reviewed. The medical record and CD-ROM based reference databases are then made available to users on a PC network in a Windows (tm) environment. Initial experience with the system

is very favorable and suggests that evaluation of patient data may be significantly enhanced.

INTRODUCTION

The traditional approach to patient care requires a clinician to seek each item of information necessary for development of diagnostic and management plans. Fortunately, routine visits to the clinical lab, radiology and the record room as well as time consuming searches through a chart are being replaced by a few keystrokes at the computer terminal. However, data organization at the computer frequently mirrors the traditional data seeking pathways. The clinician must seek each laboratory result, medication list or note and pursue a computer path to the single result that is displayed independently from critically related information. Although the computerized medical record has been recognized to be a priority in health care [1], computer-based records are not in common use [2]. If data can be organized to meet the clinician's needs then acceptance and use of computer records may increase. Just as the experienced clinician learns to rapidly move between appropriate sections of a chart, the computer must provide immediate access to all needed information [3].

The DHCP (decentralized hospital computer program) system used by Veterans Affairs hospitals provides a massive amount of patient information but exemplifies the problem. Each laboratory result, medication, X-ray or diagnosis

must be sought and viewed independent from related results. The clinician must take several menu driven steps to pursue each potentially related item of information. For example, discovery of a low hematocrit requires a search for data concerning a range of problems such as iron deficiency, renal failure, gastrointestinal bleeding or medication reaction. However, the hematocrit is routinely displayed without the trend of past results or relevant related information such as the serum iron, renal function, past diagnoses or radiology results.

While clinicians are accustomed to the process of searching for each item in the medical database, the process is not efficient and may predispose to errors and increased costs. Clearly the more difficult information is to identify the more likely it is that the data will be overlooked. Conversely, an excess of irrelevant information is similarly detrimental. In the example of a patient with a reduced hematocrit, the trend of several past hematocrits is useful but multiple screens full of daily in hospital hematocrits obscure the longer trend as well as other more important laboratory information. Suboptimal presentation of data is not only frustrating to the clinician but also contributes to inaccurate diagnosis, inappropriate or unnecessary diagnostic procedures and therapeutic errors.

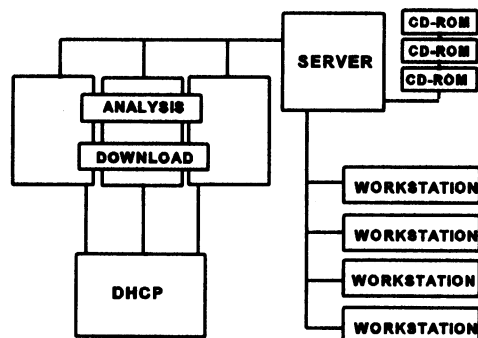
In the current environment of rapidly changing medical information, acquisition of reference and educational information is inefficient and sporadic. At the time and site of patient care in clinic or hospital rooms, needed reference information must be immediately available and very quickly accessible. If the clinician is not aware of needed facts then patient care may be delayed or inappropriate. Lack of access to reference information may induce expensive referral practices.

Optimally, the medical record should be presented such that abnormal results, trends and potential data interrelationships are immediately apparent. Results that are repetitive or of unlikely importance must be available but should be relegated to a second tier of access that does not obscure primary data. Reference and educational information must be immediately available. However, just as unnecessary patient data can obscure important relationships, irrelevant reference and educational information impedes access to needed facts. Thus, a useful medical

informatics system should provide initial organization and data links that encourage the clinician to recognize important relationships. It must then facilitate the rapid pursuit of data, references and educational information concerning alternative diagnoses and therapeutic interventions.

METHODS

Given adequate resources nearly any envisioned informatics system could be constructed. However, a system that can be widely implemented requires use of cost effective, easily available components and programming which can interface to a range of data sources. A simple PC network allows for provision of core resources while allowing the marked variation in user interface that is required by different health care providers. PC workstations allow for distributed processing capabilities and provide a cost effective, flexible platform for both data analysis and information presentation.



The current project was structured with programming and PCs that provided for four primary functions: 1) input/download, 2) cache, 3) analysis and formatting and 4) user interface. Functions were structured to be performed by parallel PCs, a design that allowed use of inexpensive machines, provided high reliability through redundancy and introduced the flexibility to meet virtually any workload through simple addition of machines. Because even a pause of a few seconds in data access is annoying and not tolerable in a busy patient care situation, it is not feasible to perform any significant degree of run time data analysis or formatting. Therefore, a fundamental characteristic of the project design

was that data would be downloaded, analyzed, formatted and linked to reference information prior to user access. Although selected sections and minor variations in the formatted record could be provided in accordance with user needs, required data is maintained in a formatted, crosslinked file that the user can obtain in a virtually instantaneous fashion.

Data Input.

The VA clinical database (DHCP) system is MUMPS based and provides data to terminals throughout the hospital. All medical record information required for this project was available within the DHCP system. Most DHCP input and access functions are adequate. However, limitations of core computer resources, slow asynchronous serial data transfer to terminals and inadequate terminal capabilities eliminated the possibility of using DHCP computers to directly implement the project. However, serial data transfer methods are widely used and provide inexpensive, easily implemented access to many sources of data. Consequently, if the project could be designed to tolerate serial data transfer then the flexibility of the data input interface would be a valuable asset.

Available patient data within the DHCP system at our facility pertinent to the current project included demographics, laboratory, radiology, pathology, pharmacy, discharge diagnosis and progress note information. Up to five years of data was available. Although existing DHCP MUMPS routines were used for some data access, in most cases routines were modified to transfer data in an abbreviated format. A DHCP "update" global was established to identify DHCP records with new laboratory, medication or radiology data. PC download computers access this global to detect which records require updating on the PC network. In addition, all patients scheduled to be seen in a clinic or who are hospitalized have their PC network files updated. Thus, data transfer to the PC network is largely a process "triggered" by activity in DHCP files.

Transfer of five years of data over an asynchronous serial link is time consuming. Therefore, to reduce data transfer but not require a duplication of DHCP storage capabilities, a file cache design was used.

File Cache.

Download PCs access the DHCP update global to identify records that require data download. The PCs then request needed records from DHCP. A new request will include all files available. After data is transferred it is temporarily stored on the PC network in a B tree database. Subsequent data requests specify that only recent data be transferred (to the date of the last database input). Because new data inputs occur in clusters (typically limited to a few days surrounding a clinic visit or hospitalization), after seven days of inactivity the temporary database files are purged. New DHCP data would subsequently induce a complete file transfer. This approach minimizes the frequency of complete record transfer as well as limiting the required PC storage space. Activity of the records of patients scheduled in clinics is anticipated and complete DHCP record downloads are requested during the weekends or nights before a clinic appointment, a process which minimizing the need for complete record transfers during the daytime periods of frequent data input.

Data analysis and formatting.

Analysis PCs (which may be the same as download PCs on a small system) access the B tree database files of each record that has been updated. The database allows rapid access to all fields in the individual medical record facilitating data evaluation. Trends and abnormalities in the data are identified. Data is then organized into a clinically relevant format that emphasizes data interrelationships, and includes links to available reference data. The formatted, summarized record is then stored on the PC network for user access. The record is updated when new data is input to DHCP. Because only information of immediate clinical relevance is kept in this record, the required file space is modest.

Reference and educational resource links.

The network allows CD-ROM database information to be made available on all network PCs. Although these information sources are of major value, access and retrieval of needed information in the busy patient care setting must be very rapid. Optimally, the data that may be required must be anticipated and directly linked to the patient record. Thus, when results such as a

low hematocrit are presented, clicking the mouse on the result of interest should provide immediate reference information concerning the differential diagnosis and management of anemia. Furthermore, within that information additional related reference or educational data should be identified and linked.

To meet the requirement for immediately accessible reference data, internal links to windows help files are installed at the time of data analysis and formatting. Microsoft Windows help files are generated in two phases. Initially RTF (rich text format) files are generated and internally cross referenced from locally generated free text and network CD-ROM sources. The RTF files are then compiled and compressed with the MS help file compiler. Very large help files can be generated and efficiently accessed. The prototype reference source includes the several complete texts, over 1000 selected journal references with abstracts and locally generated reference and guideline data. Although the initial cross referencing and generation of RTF files require a dedicated PC work continuously for several days, the complete source compiles to only 15 MB of disk space and specific topics can be accessed with virtually no delay.

Consistent with the philosophical approach to the entire project, information that is specifically relevant to the current record is directly accessible. However, the entire CD-ROM sources are available at the same workstations and more extensive information can be obtained through the standard CD-ROM programs.

Data Access

A standard Windows program is used to access preformatted, reference linked patient record files. Records can be identified by patient name, record number, clinic or hospital location. Searches are performed in a logical sequence that attempts to match patients seen by the clinician or recently treated in clinic and hospital before seeking patients with less active records.

Electronic records maintained on the PC network include demographics, scheduling, laboratory, microbiology, pharmacy, radiology, pathology, discharge diagnoses, admission and discharge summaries, problem lists and clinic notes. Information is presented in color highlighted text that can be reviewed either with standard

scrolling, accelerator keys, push-button jumps or hotspot jumps. Laboratory results are grouped in accordance with likely clinical associations. For example, serum iron results appear in proximity to the report of a low hematocrit and hepatitis B results are listed with data concerning liver function tests. The last four results of each test are listed to allow recognition of trends. Abnormal results are displayed in red and recently abnormal or rapidly changing results in pink. Potential drug related abnormalities are highlighted with yellow. Immediate jumps to any section of the record are accomplished with hotkeys or screen pushbuttons.

A double click on any laboratory result or medication brings up a windows help file screen that displays relevant data extracted from network CD-ROM sources. Help records are internally cross referenced with hotspots that facilitate rapid identification and retrieval of needed information.

RESULTS

The objectives of the project were to cost effectively provide efficient medical record and reference information access. All clinical components of the medical record needed to be accessible with no delay so that the clinician could quickly review potentially related data. These goals have been achieved. The system is now fully functional in physician offices, the emergency room, pharmacy, some clinics and at central locations for general use. Expansion to nursing stations, clinics and hospital locations is in progress. Costs of implementation are very modest. Each new location requires only that a PC be used instead of the terminal which would otherwise be required for DHCP access. Terminal functions remain available on all PCs. The serial interface with file cache between the PC network and DHCP computers has been much more effective than initially anticipated. Using only two computers for both download and data analysis, network records remain no more than 15 minutes behind new data even at peak morning hours.

Although the Boise VA hospital is a small 121 bed hospital, outpatient clinics are active with about 90,000 visits yearly. Records of all patients seen within the past year or who have a future appointment are maintained on the PC network. The initial project was established without degradation of network performance on an existing Novell network with a single 1 GB server. The concept of parallel download PCs has

been successful with respect to efficiency and reliability. Despite running unattended 24 hours/day system failure has not occurred except as the consequence of an error in a programming upgrade. Even when DHCP computers are disconnected or fail, error detection prevents PC record degradation and download computers automatically reinitiate data transfer when the serial link is restored.

Complete record download, analysis, formatting and reference linking averages just under 60 seconds. Data transfer averages 25 seconds, analysis takes 15 seconds, formatting and linking of records for network use require 10 seconds. The time required for updating database records (file cache hits) is much less.

Record access is very efficient. Because analysis and formatting is performed at the time of data transfer from DHCP, users are able to access records on screen within 0.5 second of a request. The windows GUI interface has been rapidly accepted and appears to be easily learned by most users. Security is provided through a requirement for Novell access and passwords. After five minutes of inactivity a screensaver is activated and a user's network password is required for reentry. Sensitive file access is tracked and reported to the station security officer. Computers in common use locations have the floppy drive disabled and have a modified windows interface that prevents access to any windows controls or programs other than those installed by the system manager.

Although not a focus of this report, the PC network provides many useful capabilities in addition to medical record access. Fourteen CD-ROMs on the network server provide access to multiple commercially available reference sources. CD-ROM functions have been very actively used by the full range of health care providers including physicians, residents, nurses, pharmacists, medical students and research scientists.

CONCLUSION

This pilot project has demonstrated that medical record information can be cost effectively provided in an enhanced format with integration of reference and educational information. Of importance, an efficient, easily implemented approach was utilized and demonstrated to be feasible. Because a modular approach to system

design was used, each component can be modified. The serial data interface could be replaced with an ethernet link or the simple Btree database could be replaced with any network database. Data formatting and reference links can be designed in accordance with specific user requirements.

The point of patient care is the time at which information is most needed and often is an optimal "teachable moment [4]". The clinician's interest is focussed and new information is likely to be remembered in the context of the current case. Clearly, physician education which can be achieved during patient care is efficient. Information including preventive care reminders and suggestions concerning cost effective or otherwise preferred diagnostic and therapeutic alternatives can be effectively integrated with the patient record. The use of computer based information resources in the clinic appears to be accepted by most clinicians as well as patients [5].

Medical care is information intensive in the extreme. Computers can provide massive quantities of data. However, information is of limited value without organization. The more difficult problem which this project has only begun to approach is how to optimally organize and present information which is now available.

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